COMPARISONS OF *BOS INDICUS* AND *BOS TAURUS* INHERITANCE FOR CARCASS BEEF CHARACTERISTICS AND MEAT PALATABILITY[1,2,3]

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ABSTRACT

Carcass and meat traits of 422 steers differing in the ratio of Brahman (B), Sahiwal (S) or Pinzgauer (P) to Hereford (H) and(or) Angus (A) inheritance were studied. Reciprocal backcross and F2 matings produced steers with 0:100 (H × AH and H × HA, A × AH and A × HA, HA × HA and AH × AH; or H × PH, A × PA, P × PH, P × PA, PH × PH, PA × PA), 25:75 (H × BH, A × BA, H × SH, A × SA), 50:50 (BH × BH, BA × BA, SH × SH, SA × SA, SH × BA) and 75:25 (B × BH, B × BA, S × SH, S × SA) *Bos indicus* to *Bos taurus* inheritance. Increasing the percentage of *Bos indicus* inheritance decreased carcass weights in the Brahman crosses ($P < .05$) and Sahiwal crosses ($P < .01$). The Hereford-Angus breed cross group possessed the greatest ($P < .01$) adjusted fat thickness but 12th rib longissimus muscle areas similar to those of Brahman or Sahiwal crosses. In general, marbling decreased ($P < .01$) as the percentage of *Bos indicus* breeding increased; however, maturity scores were similar among all breed groups. *Bos indicus* breed crosses were less ($P < .01$) tender and were more ($P < .05$) variable in tenderness than *Bos taurus* breed crosses. As the percentage of *Bos indicus* inheritance increased, shear values increased ($P < .01$) and sensory panel tenderness scores decreased ($P < .01$). Decreases in tenderness were associated with less desirable ($P < .01$) sensory panel ease-of-fragmentation scores and, to a lesser extent, sensory panel perception of more abundant connective tissue content of meat samples. Flavor characteristics were similar among all breed groups of cattle. (Key Words: Tenderness, Breeds, Beef, Meat, Carcasses.)

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Introduction

Crossbreeding is used widely to exploit heterosis and additive genetic variation among breeds to improve efficiency of beef production. The economic value of *Bos indicus* breeds of cattle, primarily Brahman, in crossbreeding programs in semitropical and tropical climates has been well established (Carroll et al., 1955; Cole et al., 1963; Crockett et al., 1979). In temperate climatic conditions of the U.S. Meat Animal Research Center, productivity of F1 crossbred cows (*Bos indicus* Brahman or Sahiwal sires bred to *Bos taurus* Hereford or Angus dams) has been outstanding for growth and performance traits relative to

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TABLE 1. MATING PLAN TO PRODUCE CALVES DIFFERING IN *BOS INDICUS:BOS TAURUS* INHERITANCE[a]

	Breed cross of dams						
Sire breed	HA, AH	PH	PA	BH	BA	SH	SA
H	36	12		11		11	
A	37		24		17		24
HA,AH	34						
P		19	17				
PH		21					
PA		~~23~~	23				
B				7	13		
S						18	10
BH				9			
BA					27		
SH					27	8	
SA							17

[a]Number of matings among *Bos indicus* (Brahman, B; Sahiwal, S) and *Bos taurus* (Hereford, H; Angus, A or Pinzgauer, P).

that of *Bos taurus*-cross F1 cows when mated to produce terminal-cross calves by Red Poll or Simmental sires (Cundiff et al., 1986).

Palatability and leanness are important characteristics of beef that influence consumer demand. Tenderness is the dominant palatability attribute considered by consumers in determining meat acceptability (Rhodes et al., 1955; Van Syckle and Brough, 1958). Ramsey et al. (1963), Koch et al. (1982) and Crouse et al. (1987) have observed that meat obtained from *Bos indicus* breed crosses of cattle was less tender than meat obtained from *Bos taurus* cattle. Differences in tenderness among *Bos taurus* breed crosses of cattle have not been observed to be so great (Koch et al., 1976, 1979, 1982) as differences between *Bos indicus* breed crosses and *Bos taurus* breed crosses. Other reports have indicated that meat from cattle possessing *Bos indicus* breeding is less tender than meat obtained from cattle possessing only *Bos taurus* breeding (Carpenter et al., 1961; McKeith et al., 1985).

The objectives of the research reported here were to determine the effects of 0, 25, 50 or 75% *Bos indicus* (Brahman or Sahiwal) inheritance on characteristics of carcasses and palatability of cooked meat.

Materials and Methods

Carcass and meat traits of 422 steers differing in the ratio of Brahman (B), Sahiwal (S) or Pinzgauer (P) to Hereford (H) and(or) Angus (A) inheritance were studied. Reciprocal backcross and F2 matings produced steers with 0:100 (H × AH and H × HA, A × AH and A × HA, HA × HA and AH × AH; or H × PH, A × PA, P × PH, P × PA, PH × PH, PA × PA), 25:75 (H × BH, A × BA, H × SH, A × SA), 50:50 (BH × BH, BA × BA, SH × SH, SA × SA, SH × BA) and 75:25 (B × BH, B × BA, S × SH, S × SA) *Bos indicus* to *Bos taurus* inheritance (Table 1). Each of the 22 breed lines was produced in each of 4 yr. Steers were born in March through May and weaned about October 1. After weaning, steers were fed a growing ration until February and subsequently were fed ad libitum, a mixed diet of corn silage, corn and soybean meal ranging in energy density from 2.74 Mcal of metabolizable energy (ME/kg of DM) early in the finishing period to 2.93 Mcal ME/kg late in the finishing period.

Constant feeding periods were selected that would allow animals within all breed crosses to produce carcasses that were acceptable to contemporary prevailing market conditions. In yr 1 and 2, animals were slaughtered in one of two groups during the months of June or July (35- or 41-d interval) at the laboratory facilities at the U.S. Meat Animal Research Center. In the 3rd yr, animals were slaughtered at the U.S. Meat Animal Research Center in May or June (36-d interval). In the 4th yr, steers were slaughtered at a commercial packing plant in June or July (48-d interval). Within years, about equal numbers of animals were slaughtered in each group. All steers were about 13 to 15 mo of age at slaughter. After a 24-h chill, carcasses were evaluated for USDA (1976) quality and yield grade criteria. The scoring scheme for traits observed is given in Table 2. In yr 1 through 3, the longissimus muscle corresponding to the first through fourth lumbar region was removed 24 h postmortem, vacuum-packaged, aged an additional 6 d at 1°C, frozen at −30°C and stored for up to 6 mo for subsequent shear force and sensory evaluation. In the 4th yr, the 5th through 12th rib section was removed 24 h postmortem at the commercial facility where the animals were slaughtered, transported to the U.S. MARC facility and boned, and the longissimus muscle was packaged, aged and frozen the same as for the three previous years.

Three steaks corresponding to the first through second lumbar vertebra or the 7th through 11th rib were used for shear force and sensory observations. Steaks were cut 2.5 cm thick while frozen. Sample preparation followed AMSA (1978) guidelines. Steaks were tempered 24 h in a 2 to 3°C environment and then were broiled[7]. Internal temperature was monitored with iron constantan wire thermocouples attached to a Honeywell 112 potentiometer. Steaks were turned at 40°C and removed from the broiler at 70°C. Steaks were stored in ventilated polyethylene bags for 24 h at 2 to 5°C before coring. Six 1.27-cm cores were cut such that the fiber direction of the muscle was parallel to the length of the core. Cores were sheared with an Instron 1132/Microcon II Universal Testing Instrument[8] equipped with a Warner-Bratzler type shear blade. The crosshead operated at 5 cm/min.

An eight-member descriptive attribute sensory panel was trained and tested according to methods described by Cross et al. (1978) and AMSA (1978). Panelists, in individual booths, evaluated three 1.27-cm cubed samples for juiciness, ease of fragmentation, amount of connective tissue, overall tenderness, flavor intensity and off-flavor. The scoring scheme used is given in Table 3.

Data were analyzed by least squares procedures using a model that included fixed effects for the 22 breed lines and 4 yr and covariates weaning age and days fed. The 22 breed line means and variances were then pooled by linear contrasts to form the 14 breed groups that are described in Tables 2 and 3. Animal numbers total 395 because 27 SH × BH or BA were not tabulated with the B or S groups.

[7]Farberware "Open-Hearth" broiler, Model 450N, Bronx, NY.

[8]Instron Corp., Caton, MA.

Homogeneity of variance for shear force and sensory panel traits among the 22 breed lines was tested by Bartlett's procedures (Steel and Torrie, 1980). When significant differences ($P < .05$) in variation were observed, the reciprocals of the breed line variances were used to compute the weighted least squares estimate of variance for the trait. Residual variation was used as an error term.

Results and Discussion

Carcass Traits. Least squares means and residual SD for live-animal weights and carcass traits for each of the 14 breed groups are given in Table 2. Standard errors for each breed group mean can be computed by multiplying the SE coefficient by the residual SD.

Final live weight differed ($P < .01$) among the breed groups; the Pinzgauer crosses were the heaviest, followed by Hereford-Angus crosses. The *Bos indicus* breed cross groups were lighter in weight than the *Bos taurus* breed cross groups; the Sahiwal crosses were the lightest. The 25% Brahman crosses were heavier ($P < .01$) than the 50 or 75% Brahman crosses. A similar trend in live weight was observed as the percentage of Sahiwal inheritance increased. However, increasing the percentage of Pinzgauer breeding to 75% resulted in increased ($P < .01$) live-animal weights. Increasing the percentage of *Bos indicus* inheritance greater than 25% also decreased carcass weights. The 25% *Bos indicus* weights were similar to the Hereford-Angus-cross weights.

Results for weights are in contrast with previous reports of weights of Brahman crosses in comparison with Hereford-Angus crosses at constant ages. Koch et al. (1982) observed F1 Brahman × Hereford or Angus crosses to be heavier in weight than F1 Hereford-Angus crosses. The steers produced in the study by Koch et al. (1982) were half-sibs to the dams used in the present study. Also, the sires used in the present study were the same as those used by Koch et al. (1982) to minimize drift in additive genetic effects from one generation to the next. Thus, a large portion of the increased weight advantage of the F1 Brahman × Hereford or Angus may have been due to at least twice as much heterosis in *Bos indicus* × *Bos taurus* as crosses in *Bos taurus* × *Bos taurus* (Cartwright

TABLE 2. LIVE WEIGHT AND CARCASS TRAIT MEANS AND RESIDUAL STANDARD DEVIATIONS OF BREED GROUPS DIFFERING IN PROPORTIONS OF *BOS INDICUS* AND *BOS TAURUS* INHERITANCE

		Trait												
Breed group	No.	Live wt, kg	Carcass wt, kg	Lean color score[a]	Lean firmness score[b]	Lean texture score[c]	Lean maturity score[d]	Skeletal maturity score[d]	Overall maturity score[d]	Marbling score[e]	Adj. fat thickness, cm	Longissimus area, cm^2	KPH fat, %	SE coefficient
H, A[g]	107	476	294	5.35	5.69	6.40	142.1	148.4	145.1	431	1.46	69.7	3.00	.10
Pinzgauer (P)	116	509	310	5.03	5.72	6.02	146.1	149.8	147.8	387	.98	76.6	2.96	.10
Brahman (B)	84	460	285	5.04	5.60	5.92	143.3	143.2	142.8	350	1.14	69.5	2.75	.12
Sahiwal (S)	88	418	258	4.88	5.69	6.08	144.0	146.2	145.3	355	1.03	67.3	2.70	.12
B and S	199	440	272	4.99	5.64	5.98	143.6	144.8	144.0	353	1.08	68.9	2.73	.08
1/4 P	36	508	312	5.28	5.73	6.02	142.9	148.9	146.1	421	1.26	74.2	3.01	.18
1/2 P	44	491	299	4.98	5.84	6.24	146.7	150.3	148.0	374	.94	76.1	2.85	.15
3/4 P	36	528	318	4.82	5.60	5.80	148.5	150.2	149.2	366	.74	79.5	3.02	.17
1/4 B	28	473	292	5.43	5.82	6.07	141.7	147.0	144.2	393	1.19	69.8	2.89	.20
1/2 B	36	443	276	4.82	5.68	5.95	143.8	144.0	143.3	351	1.09	68.5	2.80	.19
3/4 B	20	464	287	4.88	5.30	5.73	144.5	138.6	140.8	306	1.14	70.1	2.57	.24
1/4 S	35	462	286	4.93	5.94	6.35	143.9	151.1	147.5	377	1.07	71.4	2.69	.18
1/2 S	25	409	252	4.81	5.68	5.99	145.3	144.2	145.2	347	1.06	66.0	2.76	.22
3/4 S	28	383	235	4.91	5.46	5.89	142.8	143.2	143.2	343	.95	64.5	2.64	.20
Residual SD[f]	422	44	28	.80	.83	.75	8.1	10.0	6.8	73	.38	7.0	.59	
Breed group, *P*>F			.01	.01	.01	.39	.01	.01	.01	.01	.01	.01	.01	.01

[a,b,c]Scored: 1 = very dark, soft or coarse through 8 = very light cherry red, very firm or very fine.

[d]Scored: 100 through 199 = A.

[e]Scored: 300 through 399 = slight and 400 through 499 = small.

[f]Compute: standard error of mean = SE coefficient × residual SD.

[g]Hereford = H, Angus = A.

TABLE 3. MEANS AND RESIDUAL STANDARD DEVIATIONS FOR SENSORY PANEL SCORES AND SHEAR VALUES OF COOKED MEAT SAMPLES FROM BREED GROUPS DIFFERING IN *BOS INDICUS* AND *BOS TAURUS* INHERITANCE

	Trait																
	Shear, kg		Scores ≥ 6.95,	Juiciness[a]		Ease of fragmentation[a]		Amount of connective tissue[a]		Overall tenderness[a]		Scores ≤ 4.62,	Beef flavor intensity[a]		Off-flavor[b]		SE
Breed group	$\overline{X}$	SD	%	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	%	$\overline{X}$	SD	$\overline{X}$	SD	coefficient[c]
H, A[d]	4.40	1.00	1.0	5.23	.35	5.36	.43	5.19	.42	5.35	.44	5.6	5.04	.26	2.84	.21	.10
Pinzgauer (P)	4.95	1.42	6.0	5.20	.36	5.26	.44	5.12	.44	5.27	.45	4.3	4.96	.25	2.80	.26	.10
Brahman (B)	5.88	1.67	18.1	5.05	.36	4.88	.58	4.77	.58	4.87	.59	24.1	4.97	.22	2.86	.20	.12
Sahiwal (S)	6.90	1.90	38.6	4.96	.34	4.56	.58	4.50	.56	4.55	.60	53.4	4.93	.27	2.85	.24	.12
B and S	6.36	1.75	31.7	5.01	.35	4.73	.57	4.64	.56	4.71	.58	41.2	4.95	.25	2.85	.23	.08
1/4 P	4.97	1.08	.9	5.25	.30	5.23	.46	5.09	.43	5.24	.45	.9	4.93	.22	2.74	.25	.18
1/2 P	5.11	1.80	4.3	5.21	.37	5.27	.41	5.12	.43	5.28	.43	1.7	4.95	.26	2.80	.28	.15
3/4 P	4.76	1.18	.9	5.15	.39	5.27	.47	5.15	.47	5.29	.47	1.7	5.00	.27	2.85	.23	.17
1/4 B	5.16	1.14	7.0	5.18	.31	5.17	.41	5.04	.41	5.16	.43	7.0	5.04	.22	2.85	.23	.20
1/2 B	5.80	1.17	27.8	5.11	.40	4.92	.62	4.83	.59	4.93	.62	41.7	4.97	.22	2.83	.20	.19
3/4 B	6.68	2.12	70.0	4.86	.31	4.55	.72	4.43	.73	4.51	.72	55.0	4.92	.21	2.90	.17	.24
1/4 S	5.64	1.66	14.3	5.07	.29	4.93	.58	4.81	.54	4.93	.60	22.9	4.93	.27	2.84	.23	.18
1/2 S	6.64	1.85	48.0	5.03	.37	4.60	.55	4.60	.50	4.61	.55	60.0	4.93	.28	2.86	.27	.22
3/4 S	8.41	2.20	42.9	4.80	.38	4.14	.61	4.10	.63	4.09	.63	85.7	4.93	.27	2.83	.21	.20
Residual SD		1.50			.35		.51		.50		.52		.26			.23	
Breed group $P < F$		.01			.01		.01		.01		.01		.18			.45	
Chi-square, 21 df		84.76*			13.96		34.96*		34.01*		34.23*		15.01			19.65	

[a]Scored: 1 = extremely dry, difficult, abundant, tough or bland through 8 = extremely juicy, easy, none, tender or intense.

[b]Scored: 1 = intense through 4 = none.

[c]Compute: standard error of mean = SE coefficient × residual SD.

[d]Hereford (H), Angus (A).

*$P < .05$.

et al., 1964; Koger et al., 1975). The backcrosses and F2 progeny produced in the present phase of the experiment are expected to have only half as much heterosis as that observed in the F1 crosses. Thus, in backcross and F2 matings, *Bos indicus* × *Bos taurus* crosses stand to lose at least twice as much from their heterosis effect as *Bos taurus* × *Bos taurus* crosses, relative to heterosis effects observed in F1 *Bos indicus* × *Bos taurus* vs F1 *Bos taurus* × *Bos taurus* crosses. These results indicate that heterosis effects, rather than additive genetic effects, accounted for the superior growth observed by Koch et al. (1982) in the F1 crosses.

The Hereford-Angus-cross group possessed the greatest ($P < .01$) adjusted fat thickness (**AFT**) but had longissimus muscle areas (**LMA**) similar to LMA of Brahman or Sahiwal crosses (Table 2). The Pinzgauer breed crosses possessed the largest ($P < .01$) LMA and least AFT. Percentage of *Bos indicus* had no consistent effect on AFT or LMA. *Bos indicus* crosses possessed a lower percentage of kidney, pelvic and heart (**KPH**) fat than *Bos taurus* breed crosses. Koch et al. (1982) observed differences between *Bos taurus* and *Bos indicus* breeds for fat deposition patterns among depot sites. In contrast to our results, they observed that Hereford-Angus crosses ranked low and Pinzgauer crosses ranked high in KPH fat.

The Hereford-Angus breed cross group had the greatest ($P < .01$) amount of marbling, followed by Pinzgauer crosses. *Bos indicus* crosses possessed the smallest amount of marbling, but the Brahman and Sahiwal crosses were similar to each other in marbling. Generally, marbling decreased as the percentage of *Bos indicus* inheritance increased. Lower marbling scores were observed in both Brahman and Sahiwal crossbreed groups. This decrease in marbling was not associated with a decrease in AFT compared with other breed groups. Koch et al. (1982) and Crouse et al. (1987) previously observed that *Bos indicus* breed crosses possess less marbling than *Bos taurus* breed crosses. Kempster et al. (1976) observed that differences in fat distribution led to substantial bias for differences among breed groups when carcass fat was predicted from s.c. fat. Brahman and Brahman crosses have ranked low in breed group comparisons for marbling in other studies (Damon et al., 1960; Cole et al., 1963; Luckett et al., 1975; Young et al., 1978; Peacock et al., 1979). However, Crockett et al. (1979) reported that *Bos indicus* crossbreeds had more marbling than late-maturing, large-framed breeds of *Bos taurus* cattle.

Although statistically significant differences among breed groups for lean, skeletal and overall maturity were observed, it is doubtful that these differences were of practical importance. Hereford-Angus crosses produced meat that more finely ($P < .01$) textured than meat from Pinzgauer, Brahman or Sahiwal crosses. Crouse et al. (1987) observed that Brahman and Sahiwal crosses possessed a greater degree of dark coarse banding and darker colored lean at the 12th rib interface than Hereford-Angus crosses. Color and texture may be important to consumer acceptance; however, variation in lean color, texture, maturity and marbling within youthful carcasses have not been shown to be highly associated with variation in palatability characteristics (Campion et al., 1975; Crouse et al., 1977).

Shear Force and Palatability Traits. Means, SD and SE of shear values and sensory panel scores are given in Table 3. Also, shear values greater than 6.95 (overall $\bar{x}$ + 1 SD) and tenderness scores ≤ 4.62 (overall $\bar{x}$ − 1 SD) expressed as a percentage of the number of observations within each breed group were computed and tabulated in Table 3. The percentage values given would represent about 17% of the population at one end of the respective scales. Within-breed-group variation for traits observed was tested among breed groups by chi-square procedures. Significant variation among breed groups was observed in shear values, sensory panel ease-of-fragmentation scores, sensory panel perception of the amount of connective tissue and overall tenderness. Meat was observed to be similar for juiciness, intensity of beef flavor and off-flavor among breed groups.

As the percentage of *Bos indicus* inheritance increased, within-breed-group variation (SD) in shear values increased ($P < .05$). An increase in within-breed-group variation associated with an increase in percentage of *Bos indicus* inheritance also was observed for overall tenderness, but the increased variation was primarily within the Brahman crosses. Percentage of Pinzgauer inheritance had no consistent effect on variation in shear values or overall tenderness; however, variation tended to be greatest in the 50% crosses, in which variation in gene frequency was maximized. Variation in tenderness values was reflected in variation in ease of fragmentation and amount of connective tissue perceived by the sensory panel.

Increased shear values and decreased tenderness ($P < .01$) were observed to have been associated with increases in percentage of *Bos indicus* inheritance. The decrease in tenderness was associated with increased contribution of the Brahman or Sahiwal breeds. Sensory panelists observed 41.2% of the meat from *Bos indicus* crossbreds to have tenderness scores of less than or equal to 4.62. As the percentage of Brahman or Sahiwal inheritance increased, the percentage of tenderness scores in the lower end of the scale increased. The 3/4 Sahiwal breed group had 85.7% of the tenderness scores fall within this range of the scale. Sensory panel scores for ease-of-fragmentation and amount of connective tissue scores also were less ($P < .01$) desirable as the percentage of *Bos indicus* inheritance increased. Percentage of Pinzgauer breeding had no effect on the tenderness observations, but shear values for Pinzgauer were greater ($P < .05$) than those for the Hereford-Angus-cross group. Sensory panel scores for juiciness also decreased ($P < .01$) as the percentage of *Bos indicus* inheritance increased. Neither beef flavor nor off-flavor was affected by breed groups.

Most reports in the literature rank Brahman or Brahman crosses less tender than British breeds on the basis of shear tests or sensory panel observations, but the differences have not always been significant (Black et al., 1934; Cover et al., 1957; Damon et al., 1960; Carpenter et al., 1961; Kincaid, 1962; Ramsey et al., 1963; Carroll et al., 1964; Luckett et al., 1975; Thompson and Barlow, 1981). Koch et al. (1982) and Crouse et al. (1987) observed that F1 Brahman or Sahiwal crosses were less tender than Hereford-Angus F1 crosses. These reports indicate that obvious problems of tenderness exist in *Bos indicus* breeds of cattle. These problems seem to be independent of the environment in which animals were produced or composition of the meat. Problems associated with palatability must be solved before *Bos indicus* breeds of cattle can be utilized to optimize production efficiency in breeding programs without consideration of the negative impact of *Bos indicus* inheritance on meat palatability. Data reported here indicate that the tenderness problem probably is related to the fragmentation of the myofibril component of the muscle and, to a lesser extent, to the connective tissue portion of the lean. The biological basis of the variation in tenderness associated with *Bos indicus* breeds of cattle needs to be determined before solutions are likely to be found.

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